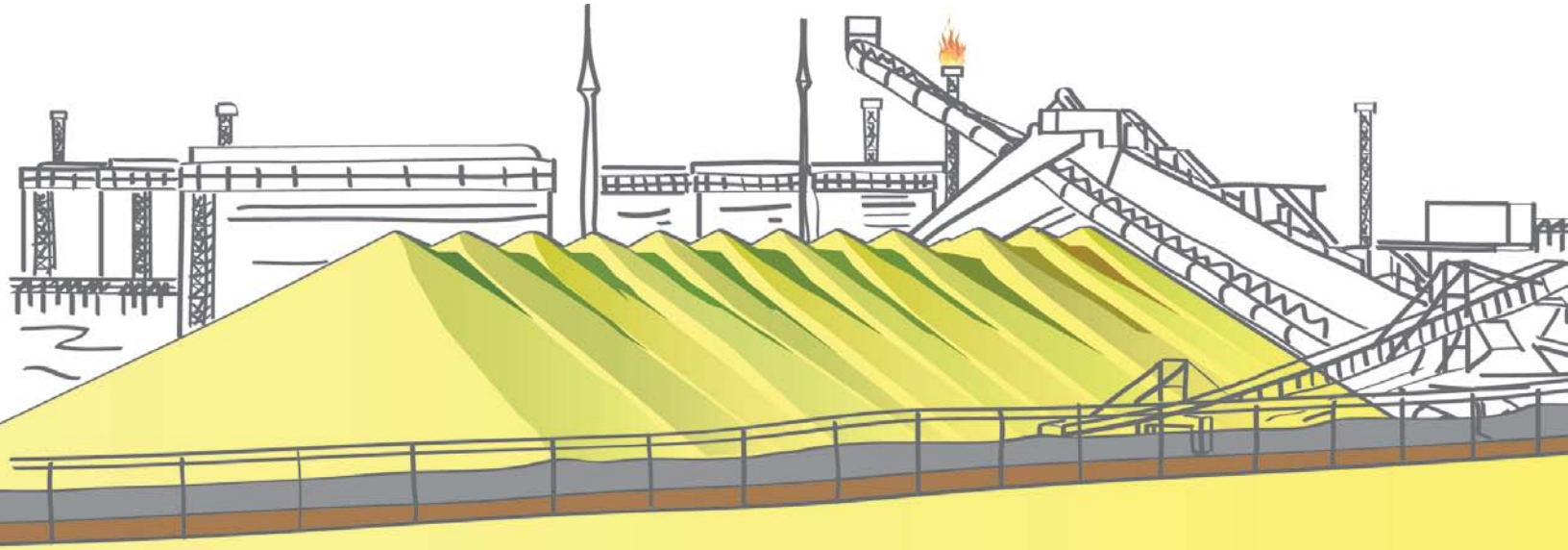
TLG-837 Tail Gas / Air Demand Analyzer

The world's safest, fastest, and most accurate Claus process analyzer.



H_2S SO_2 COS CS_2

APPLIED ANALYTICS

Applied Analytics™

We are a global manufacturer of industrial process analysis equipment. Our customers depend on our systems to keep a vigilant watch over the quality of their product, illuminate hidden phenomena occurring in their process, reduce their harmful emissions into the environment, and ensure the safety of their workers in hazardous industrial environments.

We are proud to serve the industries that keep the world running — the oil refineries, the power plants, the wastewater treatment facilities, the chemical producers, the pharmaceutical innovators, the breweries, the environmental protection agencies — and meet their analysis needs with modern, automated solutions.

Applied Analytics has been operating in the greater Boston area since our incorporation in 1994. All of our products are designed and manufactured in the USA.

» OUR TEAM

AAI's specialized role as a provider of process analysis means that 100% of our focus is permentantly dedicated to ensuring successful lifetime performance of every analyzer that we ship. Our project engineers have enormous experience with all types of applications and will guide you honestly towards the most practical and cost-effective analytical solution for your process.

» OUR TECHNOLOGY

We believe that, in the modern industrial plant, there is no longer a place for analyzers with moving parts, toxic consumables, or high costs of operation. All of our analyzers adhere to solid state design and use absorbance spectroscopy, the definite future of industrial process analysis.

» OUR SUPPORT

AAI maintains a comprehensive global support network. Our certified field engineers will always be available for site visits to assist with installation and commissioning, train personnel, and service the systems. Technical support by phone/email is included for the lifetime of the instrument.

The Claus Process

H_2S is toxic at 10 ppm, entirely lethal at 800 ppm, highly corrosive to equipment, flammable when in excess of 4.3% by volume in air, and unpleasantly odorous at a threshold of less than 1 ppb.

Unfortunately, H_2S occurs abundantly in the world's fossil fuel reserves. The sulfur recovery unit (SRU) of a refinery is dedicated to processing the H_2S stripped from the hydrocarbon fuel through a series of operations that convert it into water and harmless elemental sulfur, which can be sold and repurposed in fertilizer, gunpowder, and more.

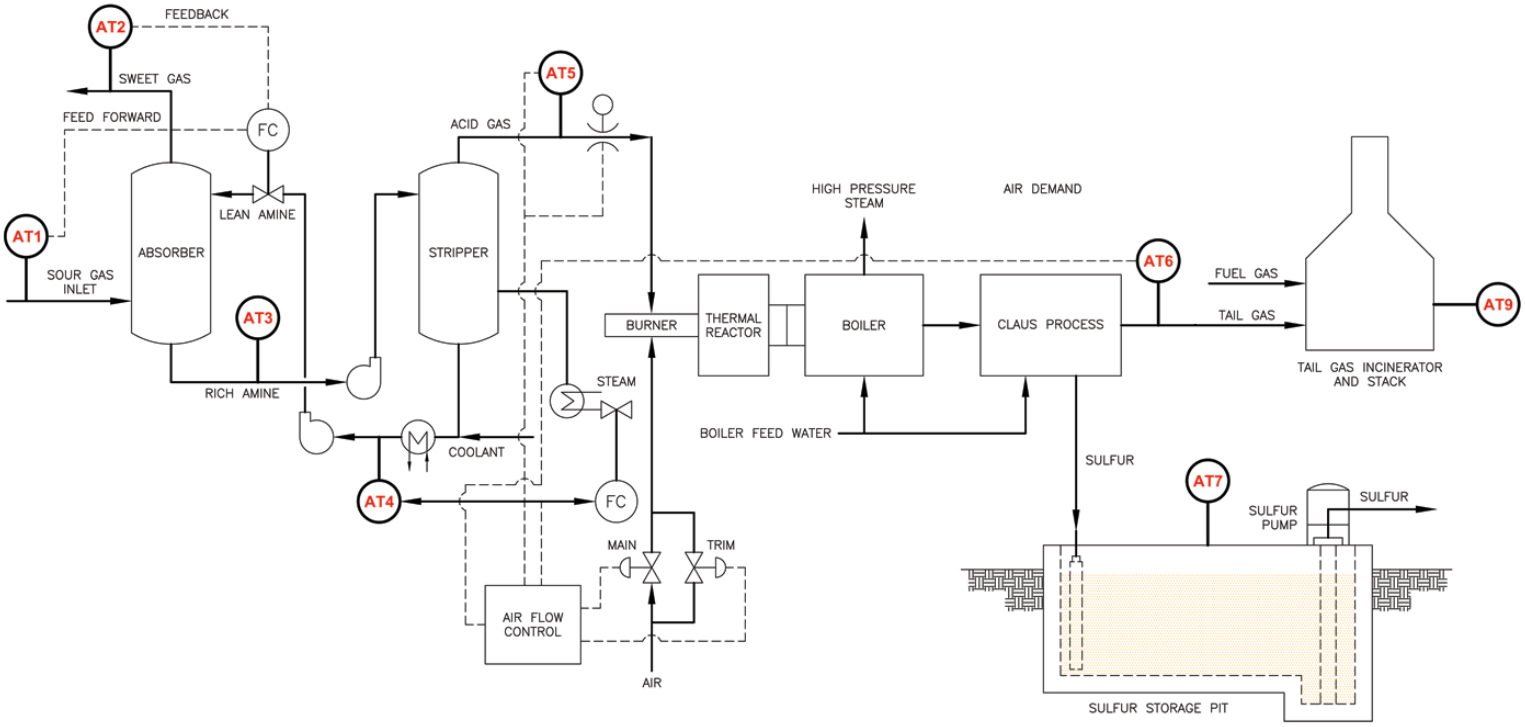
The **Claus process** is the industry standard for treating the H_2S-rich "sour" gas. In a furnace, H_2S is combusted:

$$3H_2S + {}^3/_2O_2 \longrightarrow SO_2 + H_2O + 2H_2S$$

A catalytic converter reacts the products of the combustion to create elemental sulfur in various crystalline forms:

$$2H_2S + SO_2 \longrightarrow 2H_2O + {}^3/_xS_x$$

As can be deduced from the second reaction above, the typical Claus reaction runs most efficiently when the stoichiometric ratio of H_2S to SO_2 is controlled at 2:1. The 1st reaction above demonstrates that this ratio is controlled by adjusting the amount of available oxygen.



» Tail Gas Analysis

As demonstrated above, the efficiency of sulfur recovery hinges on the ability to maintain a set H_2S/SO_2 ratio in the Claus reaction. This adjustment requires knowing the exact H_2S/SO_2 ratio in the tail gas at all times.

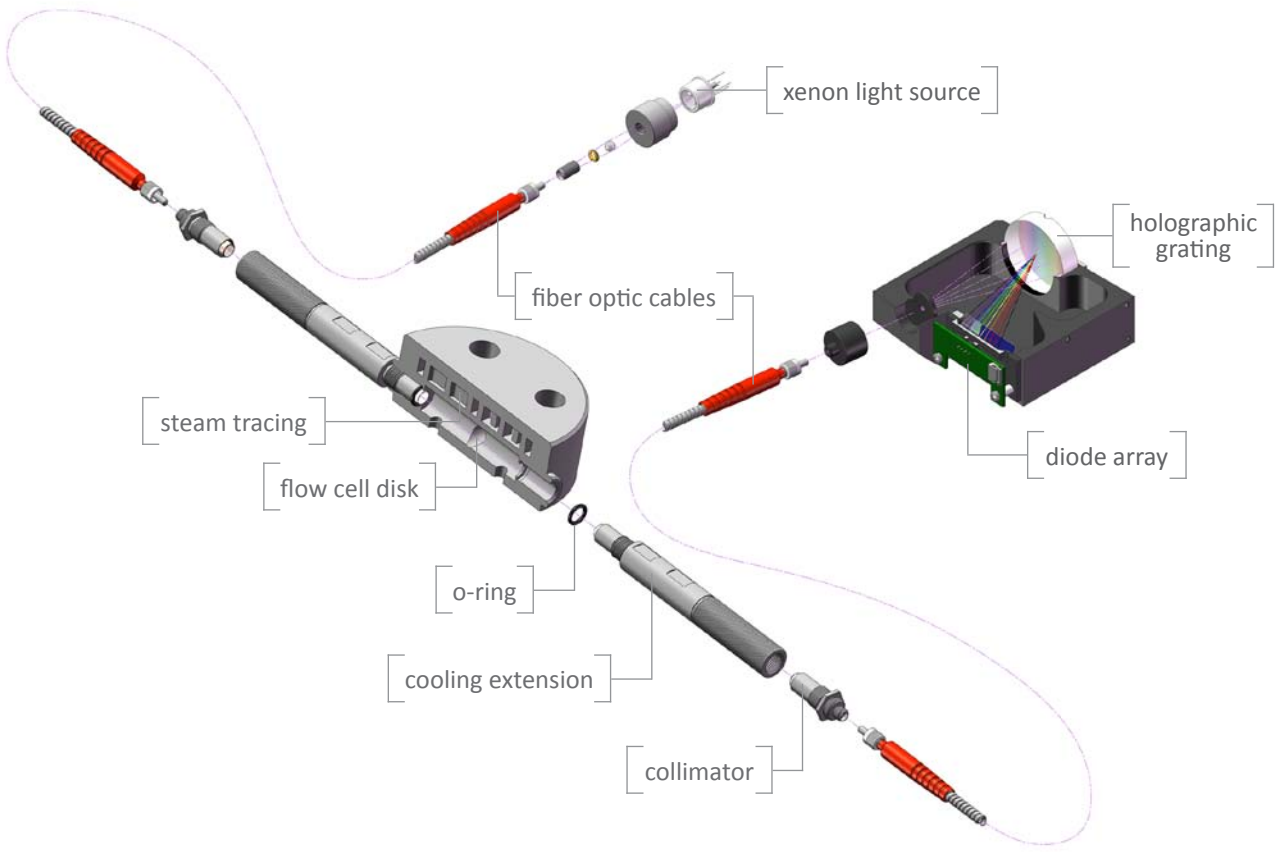
A tail gas analyzer measures H_2S and SO_2 in the stream and continuously outputs the "Air Demand" control signal, caclulated by multiplying the expression ($2[SO_2] - H_2S$) by a scaling factor. Additionally, operators sometimes require online measurement of COS and CS_2 due to side reactions in the reactor.

TLG-837 Analysis Principle of Operation

The analyzer uses a high resolution UV-Vis spectrophtometer to acquire a 200-800 nm absorbance spectrum of the sample gas. Within this spectrum, the analyzer can identify the distinct absorbance curves of each analyte, measure the height of these curves, and correlate that value directly to real-time concentration.

» Optical Assembly

The optical assembly of the TLG-837 is depicted below, illustrating the complete path of the signal.



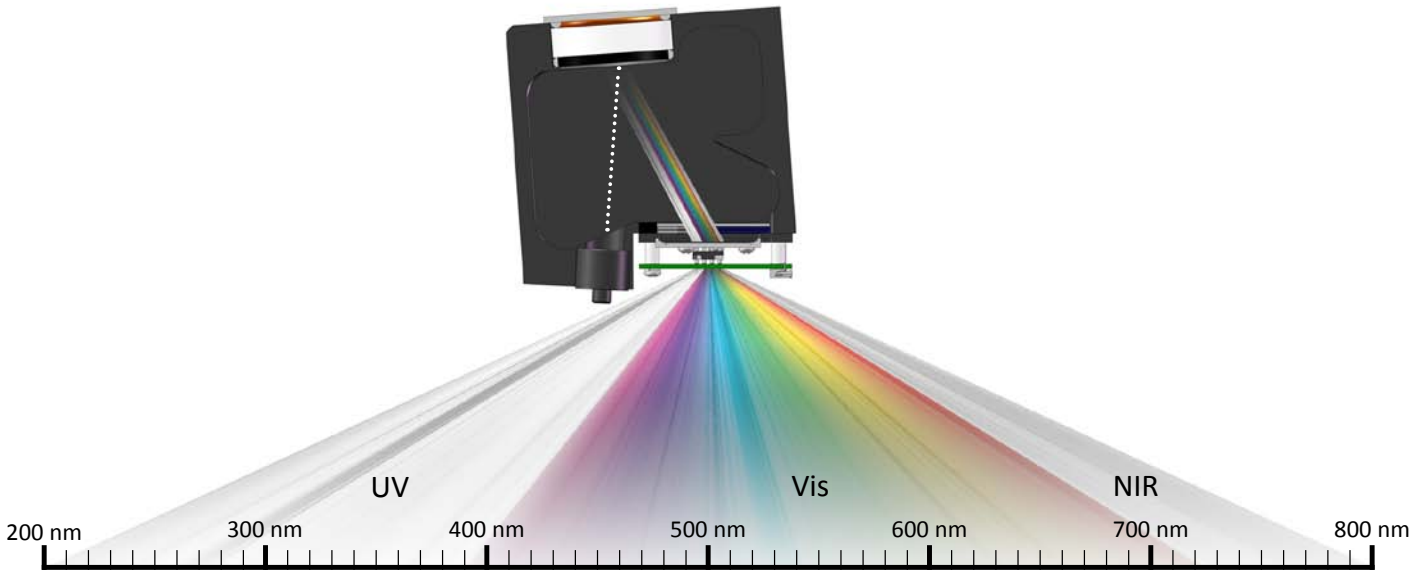
The signal originates in the pulsed xenon light source and travels via fiber optic cable to the `flow cell disk, which is built into the head of the probe. Passing through the length of the flow cell, the signal picks up the absorbance imprint of the continuously drawn sample gas.

Exiting the flow cell on the opposite end, the signal travels by fiber optic cable to the spectrophotometer, where a holographic grating separates the signal into its constituent wavelengths, focusing each wavelength onto a corresponding photodiode on a 1024-diode array. This is known as *dispersive* spectrophotometry.

» Full-Spectrum Analysis

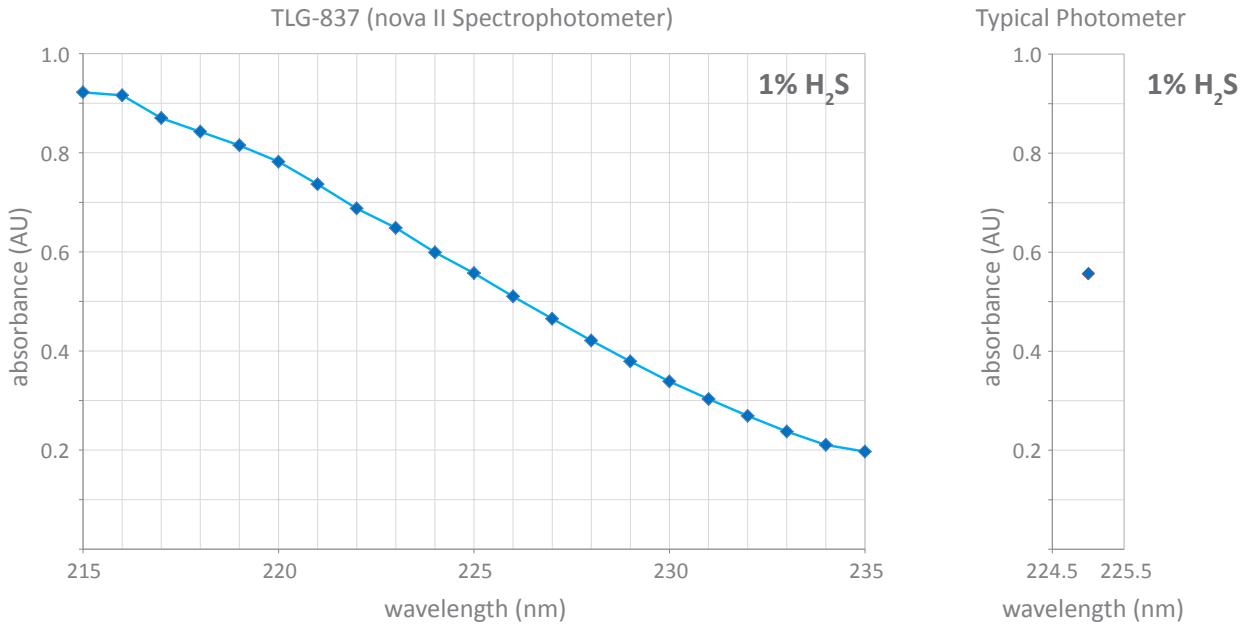
A conventional 'multi-wave' photometer measures a chemical's absorbance at one pre-selected wavelength with one photodiode. This 'non-dispersive' technique uses an optical filter or line source lamp to remove all wavelengths but the pre-selected measurement wavelength.

By contrast, the TLG-837 uses a dispersive spectrophotometer to acquire a full, high-resolution spectrum. Each integer wavelength in the spectral range is individually measured by a dedicated photodiode.



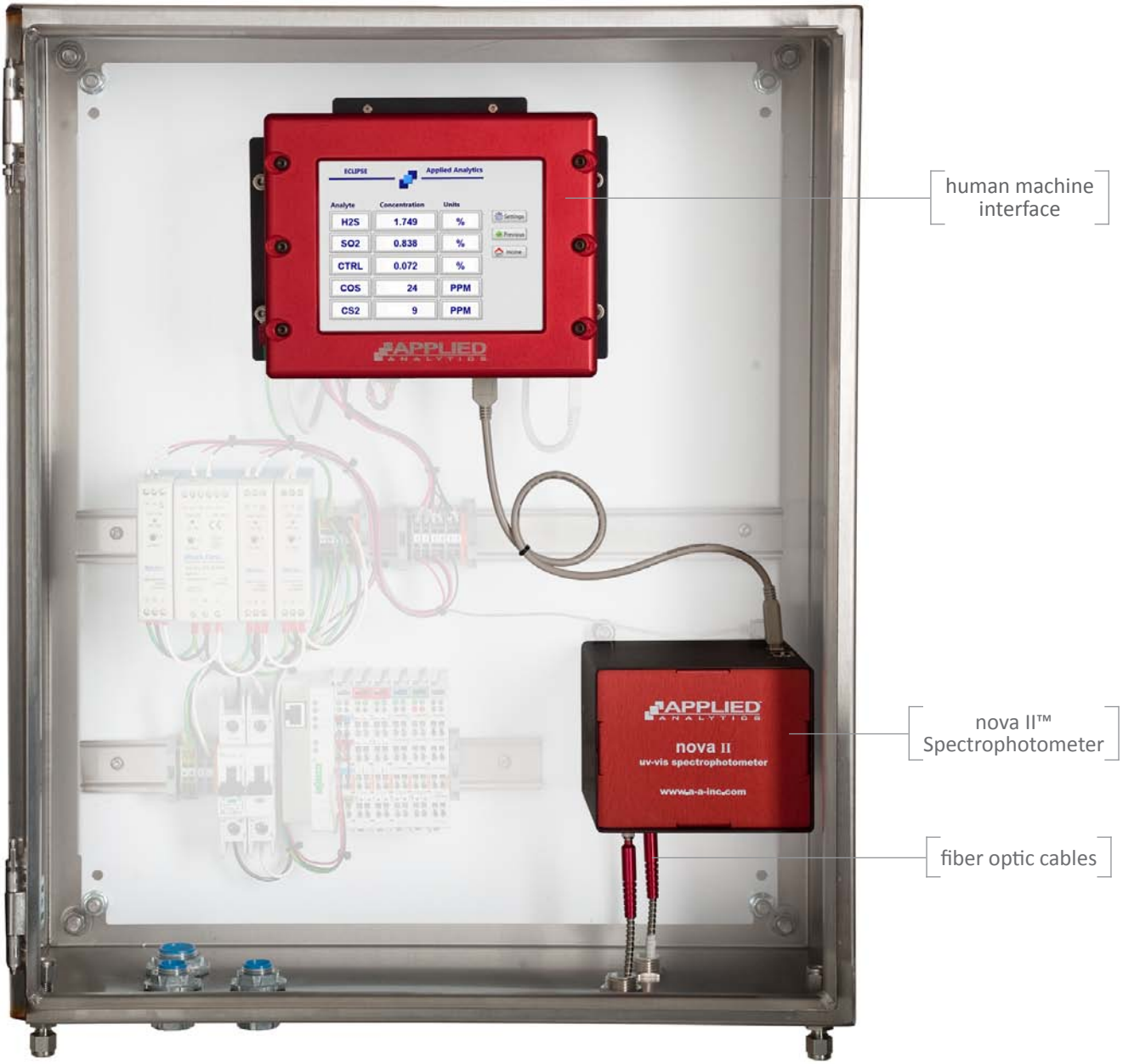
» The Accuracy Advantage of Collateral Data

A single photodiode is susceptible to noise and signal clipping. As accepted in the lab community for decades, the only way to eradicate this source of error is to use many photodiodes measuring at many wavelengths. Compiling the data from all these photodiodes produces an absorbance spectrum instead of a single data point:



Analyzer Overview

The internal components of the TLG-837 analyzer unit are indicated below (door removed):



» **Human Machine Interface**

The HMI controlling the spectrophotometer and communication provides a simple, touch-screen visual interface. Running our proprietary ECLIPSE software, the HMI offers the user several display choices (e.g. standard numeric display, trendgraph, bar graph).

From this interface, the user can quickly perform tasks and adjust settings, including:

- Auto Zero scheduling
- Alarm configuration

- Analog ouptut configuration
- Adjust data storage settings for concentration log and spectra log
- Change units of concentration
- Optional Auto Span
- Air Demand formula definition

» nova II™ UV-Vis Spectrophotometer

The heart of the TLG-837 is the diode array spectrophotometer. This device contains the light source as well as the detector which measures the absorbance spectrum.

A highly evolved device, the nova II has several distinctive features which allow it to excel in tail gas analysis:

- Solid state build with excellent wavelength stability
- CMOS analog circuitry reduces noise and power consumption
- 1024-element diode array with ~1nm resolution
- Strong light throughput in low UV region
- Very low stray light due to design without mirrors or filters
- Ethernet interface for remote access
- Xenon light source with 5 year lifespan

» Fiber Optic Cables

Our fibers are all manufactured in-house to ensure spectroscopic-grade quality. The stainless steel cladding provides proven durability in the field. Before shipment, each fiber is tested to ensure it meets transmission benchmarks, Exceptional UV light transmission is achieved through our presolarization technique.

The fibers connect to the flow cell through rugged steel collimators, and are thus not wetted to the sample fluid. Optional cooling extensions provide further protection from hot samples.

» Voltage/Current Interface Module

This device receives digital information from the HMI and converts it to 4-20 mA analog signals, the industrial standard for communication with the DCS.

» Solid State Drive

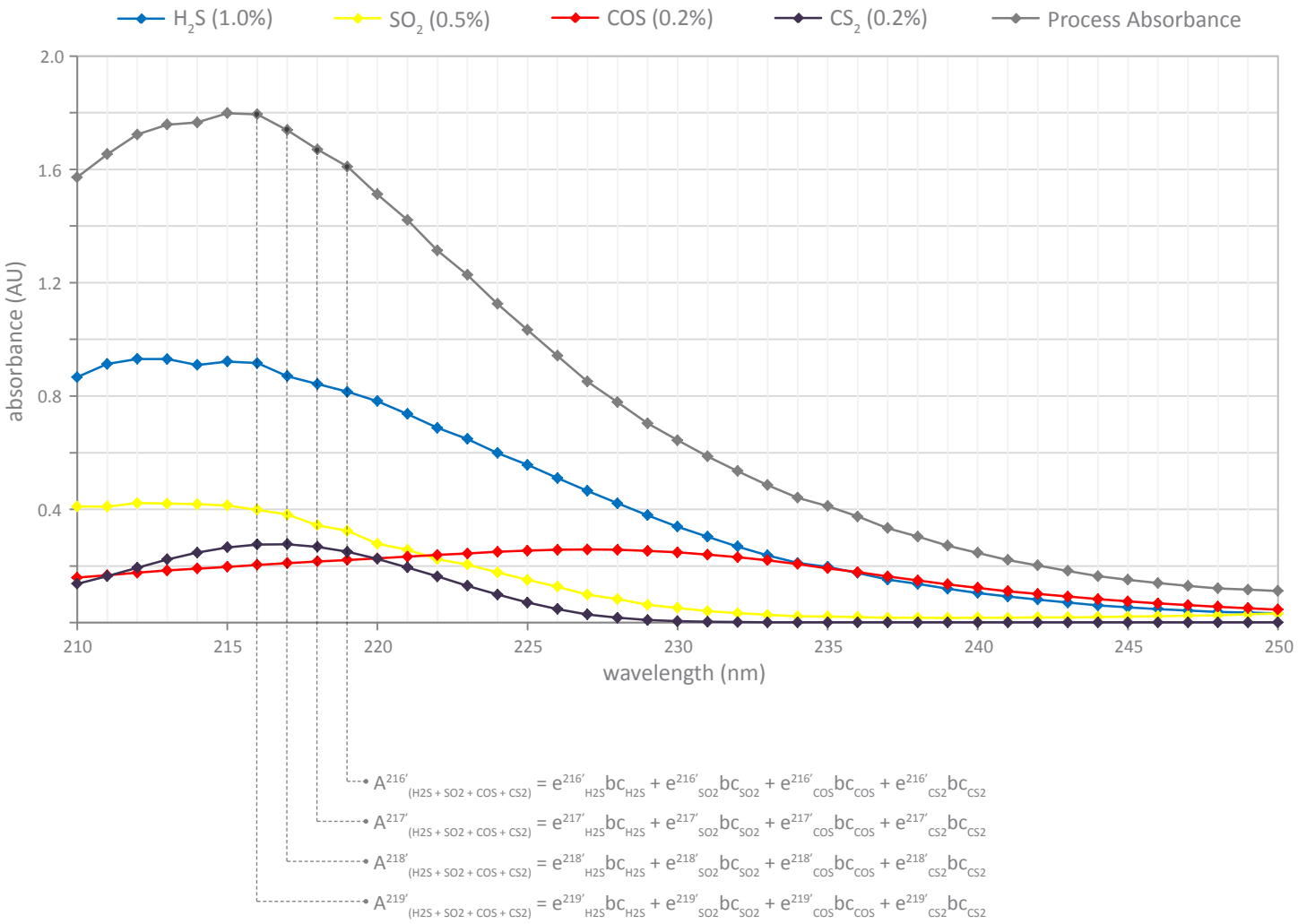
The HMI runs ECLIPSE software off of a solid state drive (SSD) with ample storage for saving historical measurement data. Spare SSDs have the ECLIPSE software preloaded and can easily be swapped in with minimal downtime.

Multi-Component Analysis

The ECLIPSE software is able to measure H_2S, SO_2, COS, and CS_2 simultaneously by de-convoluting the absorbance curve of each analyte from the total sample absorbance structure. This method is unique, as it does not require physical wavelength isolation. While other systems utilize moving parts (e.g. filter wheels) or multiple line source lamps (each requiring replacement), the TLG-837 uses the power of rich data and adheres to a simple, solid state design with a single, long-life light source.

» De-Convoluting the Spectra

Multi-component spectroscopy is made possible by the principle of additivity: according to Beer's law, the absorbance of a mixture at any wavelength is equal to the sum of the absorbance of each chemical in the mixture at that wavelength.



The TLG-837 measures the total absorbance curve of the tail gas and solves for the individual absorbance curves of the analytes by using a matrix of equations. As illustrated above, each photodiode-wavelength combination supplies a single equation to the matrix, in the form:

$$A'_{(x+y)} = A'_x + A'_y = e'_x bc_x + e'_y bc_y$$

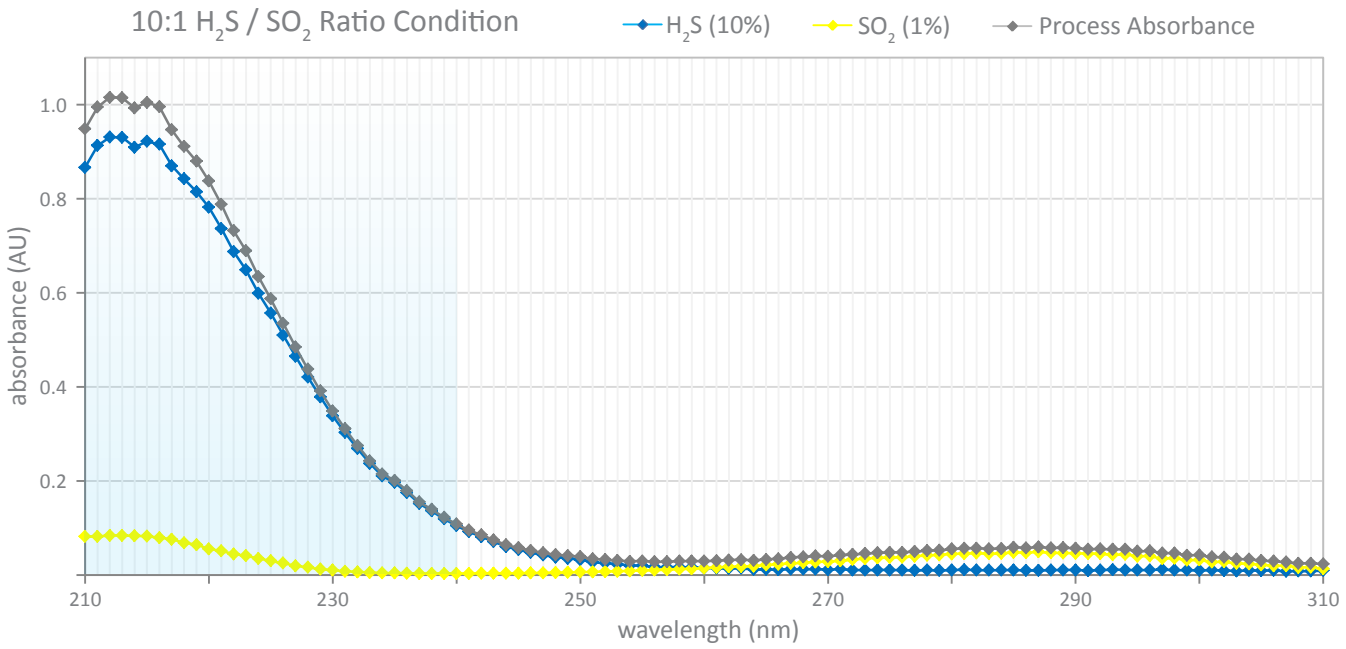
Where A' is the absorbance at wavelength ', e' is the molar absorptivity coefficient at wavelength ', c is concentration, and b is the path length of the flow cell.

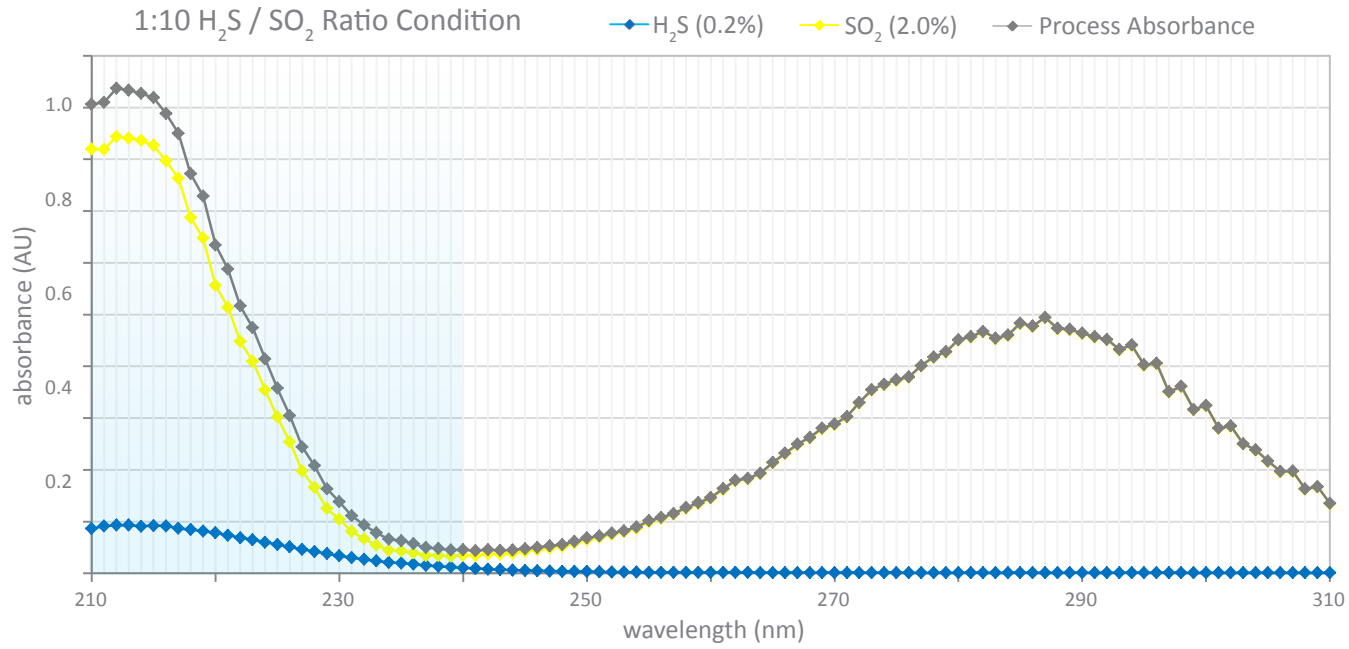
Off-Ratio Performance

Under upset conditions, the H_2S/SO_2 ratio may deviate widely from the desired 2:1 optimization point; also, some modified Claus processes operate with a controlled ratio much higher than 2:1. A high-performing tail gas analyzer must therefore sustain accuracy when the ratio is outside the expected range ('off-ratio' conditions).

In a multi-wave photometer, the response to concentration change is limited by a single photodiode's ability to measure swings in absorbance. That lone diode is highly susceptible to noise and signal clipping at out-of-range absorbance. The TLG-837 spectrophotometer overcomes this constraint by using a 1,024-diode array; the full spectrum has regions of measurement wavelengths that are suited to different scenarios, while statistical averaging of each diode's reading serves to eradicate noise.

By virtue of full spectrum acquisition, the **TLG-837 sustains specified accuracies when H_2S/SO_2 ratio reaches as high as 100:1 or as low as 1:20**. This dynamic range is unrivaled in tail gas analysis.

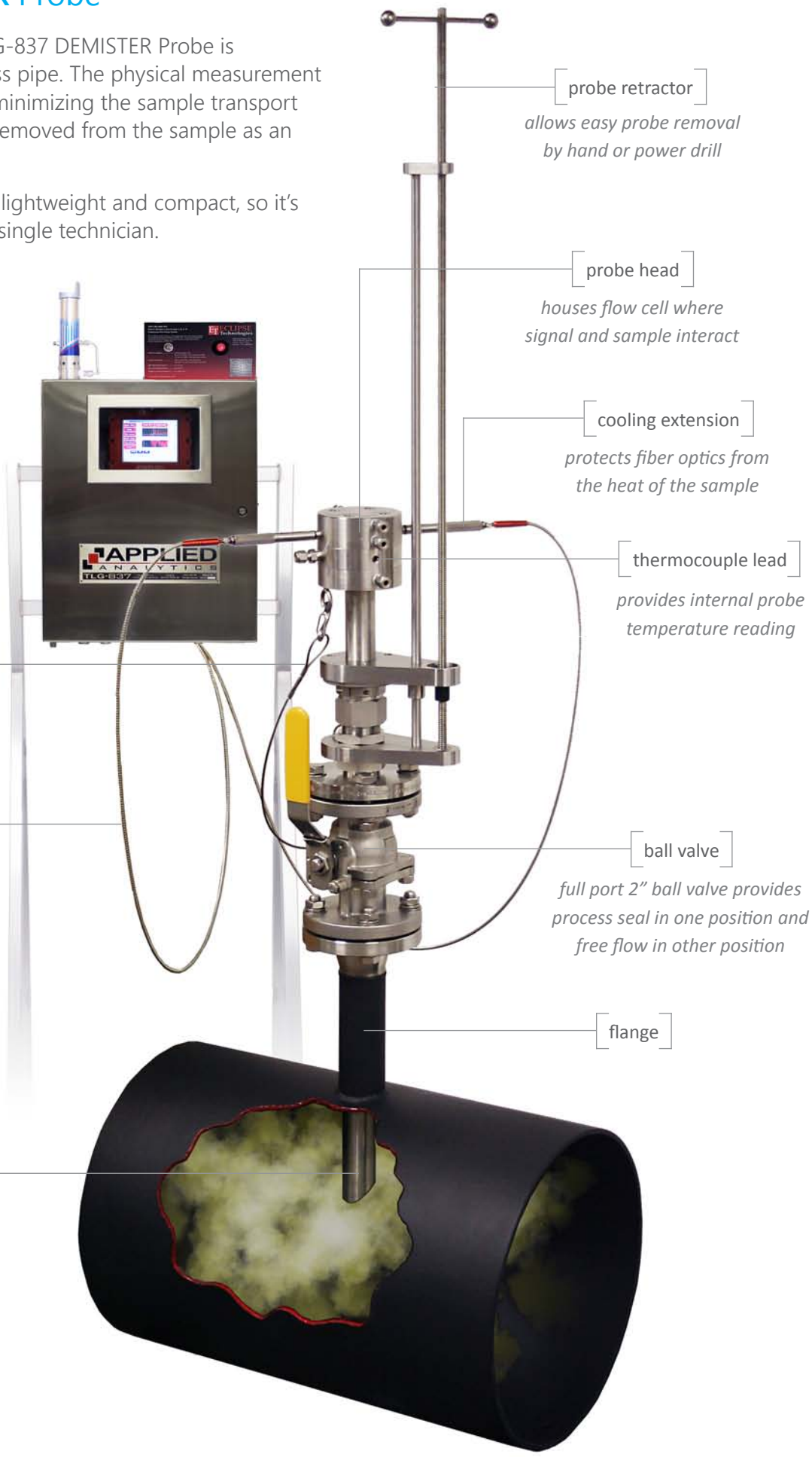




The *in situ* **DEMISTER** Probe

Applied Analytics' patented TLG-837 DEMISTER Probe is mounted directly on the process pipe. The physical measurement occurs inside the probe head, minimizing the sample transport time. Entrained sulfur vapor is removed from the sample as an internalized function.

This probe was designed to be lightweight and compact, so it's easy to install and service by a single technician.



probe retractor
allows easy probe removal by hand or power drill

probe head
houses flow cell where signal and sample interact

cooling extension
protects fiber optics from the heat of the sample

thermocouple lead
provides internal probe temperature reading

safety cable
fail-safe to prevent spontaneous probe ejection

fiber optic cables
transmit light signal b/w analyzer and probe

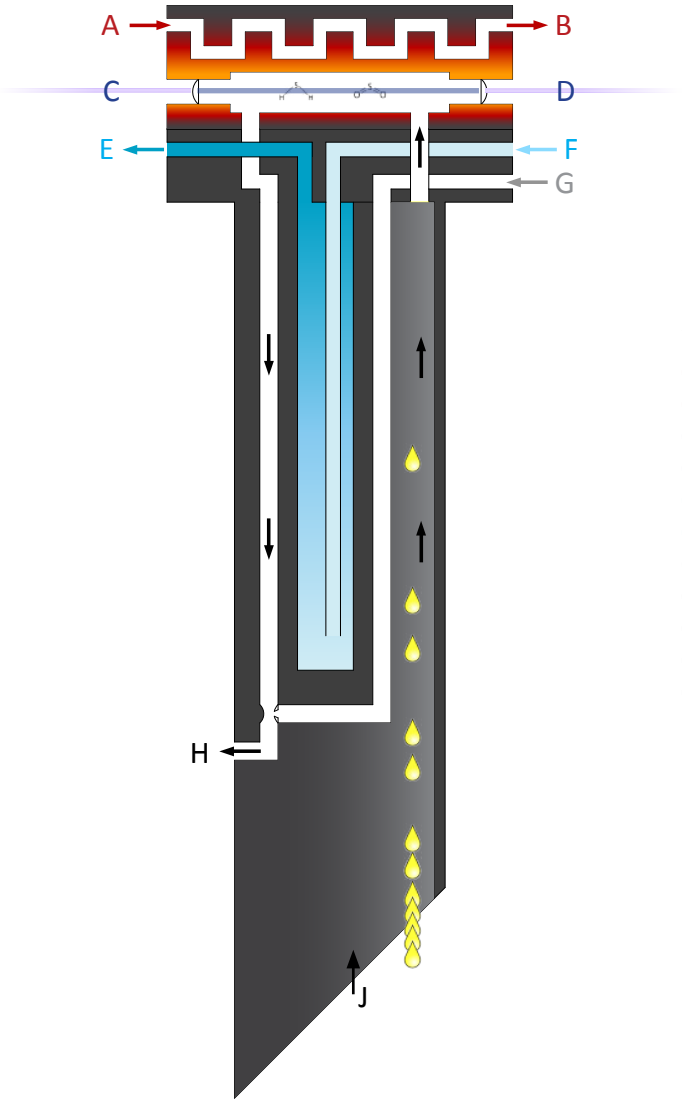
ball valve
full port 2" ball valve provides process seal in one position and free flow in other position

flange

angled inlet tip

» Automatic Sulfur Vapor Removal

Tail gas contains elemental sulfur which is quick to condense and plug mechanical cavities or obstruct optical signals. The DEMISTER Probe removes sulfur from the rising sample as an internalized function within the probe body. Recycling the steam generated by the Claus process, the probe controls the temperature along its body at a level where all sulfur vapor in the rising sample condenses and drips back down to the process pipe.



Schematic Legend:

(A) High-Pressure Steam In
(B) Steam Out
(C) Light Signal In
(D) Light Signal Out
(E) Steam Out
(F) Low-Pressure Steam In
(G) Aspirator Air In
(H) Sample Return Point
(J) Sample Entry Point
(💧) Liquid Sulfur Droplet
(→) Sample Route

Inside the probe, an internal 'demister' chamber (concentric to the probe body) is fed with low pressure steam (see **E** & **F**). Since the LP steam is much cooler than the tail gas, this chamber has a cooling effect on the rising sample.

Elemental sulfur has the lowest condensation point of all of the components in the tail gas. Due to the internal probe temperature maintained by the LP steam, all of the elemental sulfur in the rising sample is selectively removed by condensation while a high-integrity sample continues upward for analysis in the probe head.

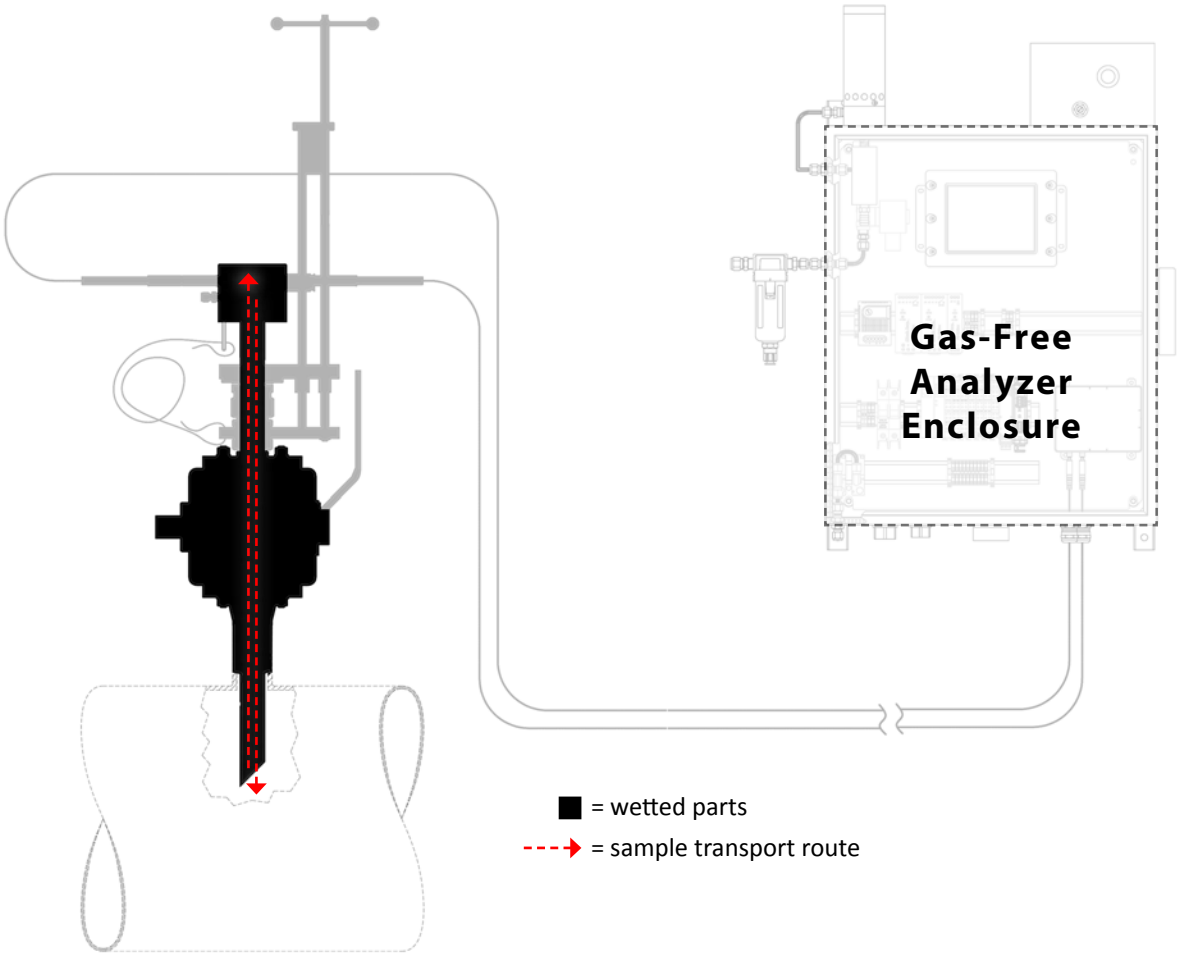
The point of interaction between the light signal and the sample gas occurs in the flow cell disk inside the probe head (**C** & **D**). The flow cell disk has a built-in HP steam channel (**A** & **B**) to heat the cell and ensure that any present sulfur remains gaseous—eliminating the possibility of condensation on the optical windows.

An aspirator (**G**) creates a Venturi effect which pulls the sample up the probe body intake path, through the flow cell for analysis, and down the return line. The used sample is released back into the process pipe (**H**).

An **Ultra-Safe** Tail Gas Analyzer

Applied Analytics design centers on inherent safety. The major safety flaw of other tail gas analyzers is that they bring the toxic sample fluid into the analyzer enclosure for analysis. Not only does this practice expose the system electronics to higher corrosion effects, it also poses a lethal threat: if there is any leak in the instrument — especially inside a shelter — the human operator is placed at enormous risk.

The key difference between the TLG-837 and other tail gas analyzers is the use of fiber optic cables: **we bring the light to the sample instead of bringing the sample to the light.** The toxic sample only needs to circulate through the probe, and never enters the analyzer electronics enclosure.



» **Key Safety Features**

- No danger of leaks inside the analyzer because the tail gas does not enter the analyzer enclosure
- No need for a shelter — system designed for outdoor environment
- Custom fiber length up to 6 meters allows for distance between analyzer and probe
- User can safely perform service on the analyzer while process is running — no exposure to sample gas
- Digital link (e.g. Modbus) provides additional process data during any upset conditions — personnel do not need to physically visit the analyzer during potentially dangerous situations
- Full port 2" ball valve provides process seal, allowing isolation and removal of probe while process running

The Optional Utility Control Panel

In order to regulate the pressure of the steam going to the DEMISTER Probe, the user can build their own panel or purchase the optional TLG-837 Utility Control Panel (UCP). Standard functions of the UCP include:

- Regulates LP steam pressure for demister chamber in probe body
- Regulates HP steam pressure for flow cell steam tracing in probe head
- Provides zero gas for Auto Zero sequence
- Provides span gas in case Auto Span is desired
- Controls aspirator flow rate
- Provides steam failure blowback feature: in the event of faulty steam utilities, the flow cell disk is sealed from the sample and the cell is purged with nitrogen from the UCP

With the features above, the UCP is a standardized panel engineered for turnkey integration. *Note: no part of UCP is wetted to sample.*

Unattended Operation

The TLG-837 only requires a one-time calibration during installation. Designed for unattended operation, the system depends on Auto Zero to maintain accuracy. This automated task normalizes the spectrophotometer reading while running a zero-absorbance gas (e.g. nitrogen) through the flow cell.

When Auto Zero initiates (following a user-defined schedule), the ECLIPSE software automatically operates the appropriate valves via relays to purge the flow cell with zero gas and save a new zero spectrum.

normal runtime

Auto Zero

In a typical usage profile, Auto Zero is set to run every 8 hours. The task requires approximately 120 seconds during which the measurement output is frozen. Under these settings, the **TLG-837 can provide greater than 99.5% analyzer uptime.**

Technical Specifications

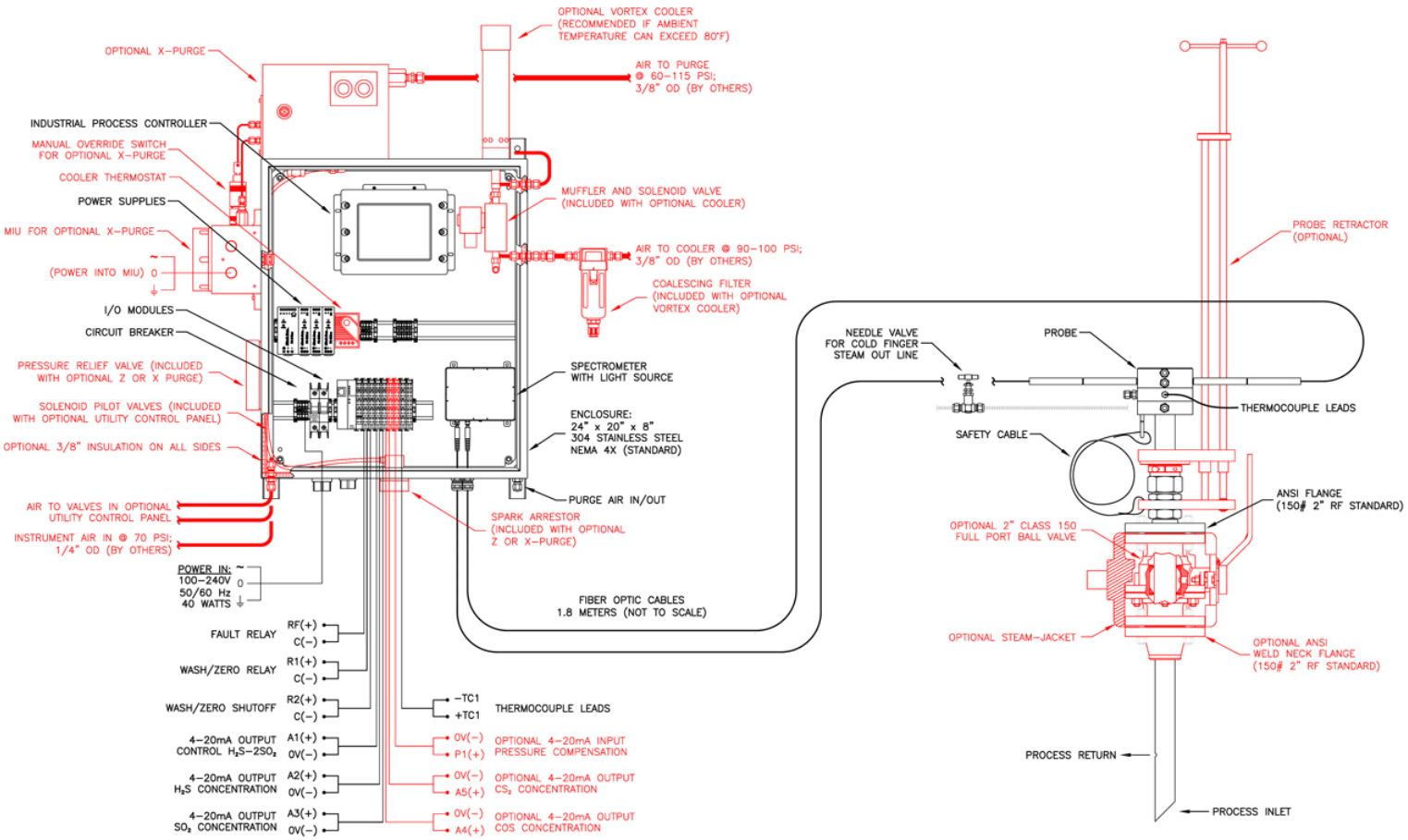
Note: All performance specifications are subject to the assumption that the sample conditioning system and unit installation are approved by Applied Analytics. For any other arrangement, please inquire directly with Sales.

Subject to modifications. Specified product characteristics and technical data do not serve as guarantee declarations.

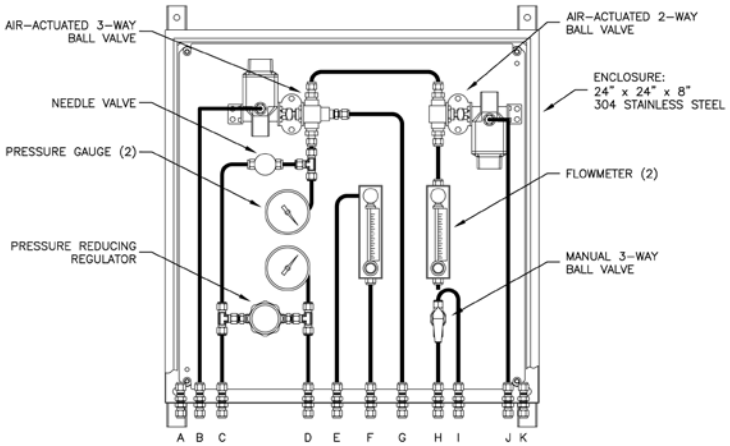
General				
Measurement Principle	Dispersive UV-Vis absorbance spectrophotometry			
Detector	nova II™ diode array spectrophotometer			
Spectral Range	200-800 nm			
Light Source	Pulsed xenon lamp (average 5 year lifespan)			
Fiber Optic Cables	Standard: 1.8 meter 600 µm core fibers. *Longer lengths available.*			
Sample Introduction	In Situ DEMISTER Probe			
Analyzer Calibration	One-time calibration at factory or site with certified calibration gas (never requires re-calibration)			
Verification	Simple verification with samples or neutral density filters			
Human Machine Interface	Industrial controller with touch-screen LCD display running ECLIPSE™ Software			
Data Storage	Solid State Drive			
Certifications	Standard: Class I, Division 2 Optional: Class I, Division 1; ATEX Exp II 2(2) GD; *various other certifications available.*			
Measuring Parameters				
Accuracy / Repeatability	Analyte	Typical Range	Accuracy	Repeatability
	H_2S	0-2%	±1% of measurement	±0.4%
	SO_2	0-2%	±1% of measurement	±0.4%
	Air Demand	User-defined	±1% of measurement	±0.4%
	COS	0-2,000 ppm	±1% of measurement (±5% under 500 ppm)	±0.4%
	CS_2	0-2,000 ppm	±1% of measurement (±5% under 500 ppm)	±0.4%
Off-Ratio Range	100:1 > H_2S/SO_2 ratio > 1:20			
Response Time (T_{10} - T_{90})	10 seconds			
Zero Drift	±0.1% after 1hr warm-up, measured over 24hrs at constant ambient temperature			
Sensitivity	±0.1% full scale			
Noise	±0.004 AU at 220 nm			
Ambient Conditions				
Ambient Temperature	Standard: 0 to 40 °C (32 to 104 °F) w/ Temperature Control: -20 to 55 °C (-4 to 131 °F) *To avoid radiational heating, use of a sunshade is recommended for systems installed in direct sunlight.*			
Environment	Indoor/Outdoor — no shelter required			
Physical Specifications				
Wetted Materials	Standard: Stainless Steel 316/316L, Kalrez. *Other materials available.*			
Analyzer Enclosure	Standard: wall-mounted NEMA 4X stainless steel type 304 Enclosure. *Other enclosures available.*			
Probe Material	Standard: Stainless Steel 316/316L. *Other materials available*			
Size	Analyzer: 24"" H x 20"" W x 8"" D (610mm H x 508mm W x 203mm D) Prove Average Dimensions: 36" length x 12" widest diameter (914mm x 305mm) Optional Utility Control Panel: 24" H x 24" W x 8" D (610mm H x 610mm W x 203mm D)			
Weight	Analyzer: 32 lbs. (15 kg) Prove Average Weight: 29 lbs. (13 kg) Optional Utility Control Panel: 25 lbs. (11 kg)			
Utility Requirements				
Electrical Requirements	85 to 264 VAC 47 to 63 Hz			
Power Consumption	45 watts			
Instrument Air Requirement	70 psig (-40 °C dew point)			
Steam Pressure Requirement	70 psig for DEMISTER chamber 30-50 psig for probe blowback function 75-100 psig for optional ball valve steam jacket			

Outputs / Communication	
Standard Outputs	1 galvanically isolated 4-20mA output per measurement 2 digital outputs for fault and SCS control
Optional Outputs	Modbus TCP/IP; RS-232; RS-485; Fieldbus; Profibus; HART; *more*

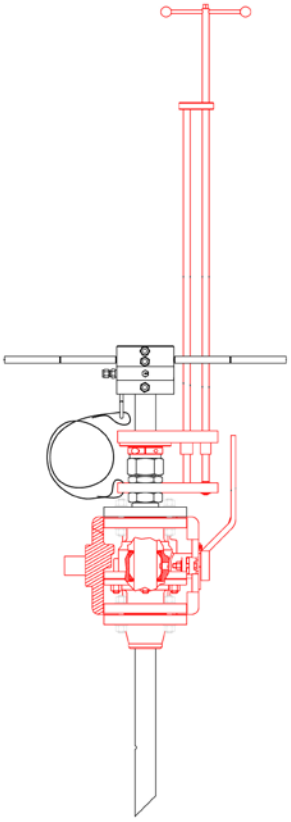
» Model TLG-837 Technical Drawing



» Utility Control Panel Technical Drawing



A. PURGE AIR IN/OUT, 1/4" OD
B. AIR TO VALVE 1, 1/4" OD
C. STEAM IN, 1/4" OD
D. STEAM TO COLD FINGER, 1/4" OD
E. AIR TO ASPIRATOR, 1/4" OD
F. ASPIRATOR AIR IN, 1/4" OD
G. TO FLOW CELL, 1/4" OD
H. SPAN, 1/4" OD
I. ZERO (N_2), 1/4" OD
J. AIR TO VALVE 2, 1/4" OD
K. PURGE AIR IN/OUT, 1/4" OD



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